NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

REPLY TO
ATTN OF: GP

March 30, 1971

TO: USI/Scientific & Technical Information Division
Attention: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned U.S. Patents in STAR

In accordance with the procedures contained in the Code GP to Code USI memorandum on this subject, dated June 8, 1970, the attached NASA-owned U.S. patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No. : 3,393,330

Corporate Source : Lewis Research Center

Supplementary Corporate Source :

NASA Patent Case No.: XLE-01903

Gayle Parker

Enclosure:
Copy of Patent

N71 23599 (ACCESSION NUMBER)
(THRU)
6 (PAGES)
00 (CODE)
(NASA CR OR TMX OR AD NUMBER)
(CATEGORY)
FACILITY FORM 602

MAY 1971
RECEIVED
NASA STI FACILITY
INPUT BRANCH

NASA-HQ

N71-23599

July 16, 1968 A. VARY 3,393,330

THERMIONIC CONVERTER WITH CURRENT AUGMENTED
BY SELF-INDUCED MAGNETIC FIELD
Filed June 24, 1965

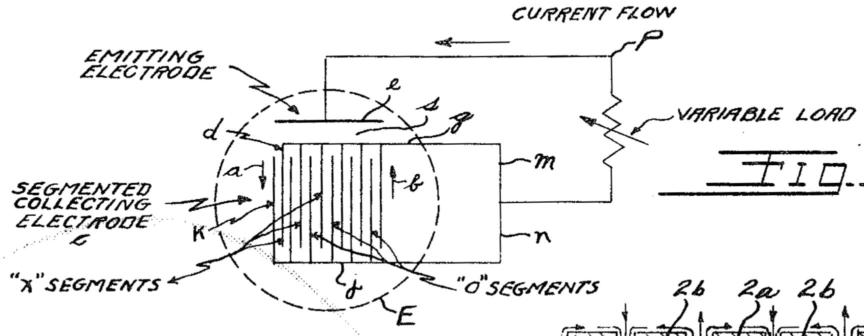

FIG. 1

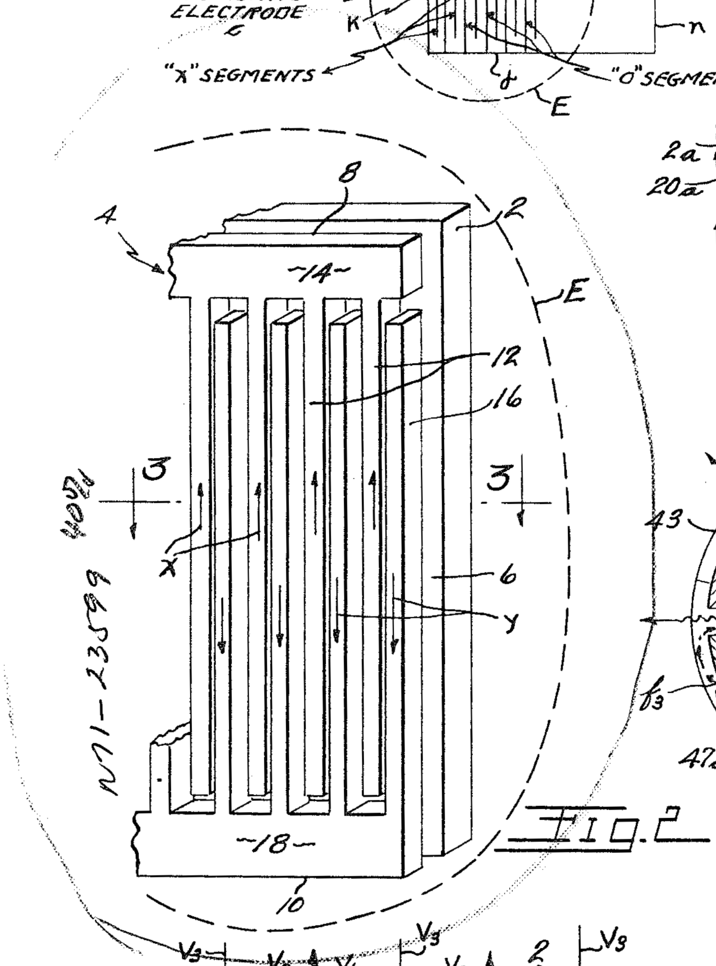

FIG. 2

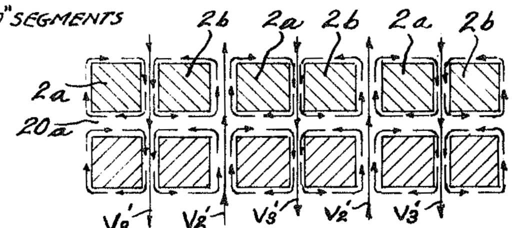

FIG. 4

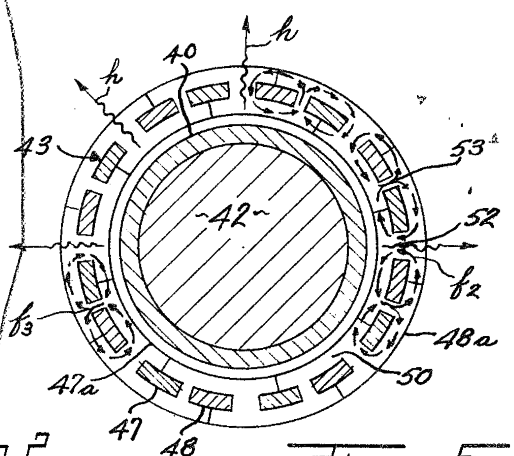

FIG. 5

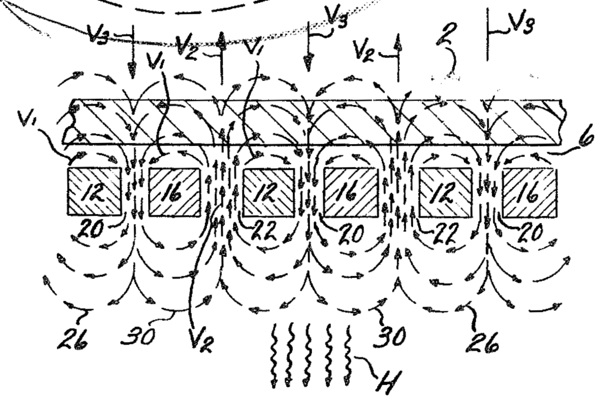

FIG. 3

INVENTOR
ALEX VARY

BY [signature]
[signature]
ATTORNEYS

1414

United States Patent Office

3,393,330

Patented July 16, 1968

3,393,330
THERMIONIC CONVERTER WITH CURRENT AUGMENTED BY SELF-INDUCED MAGNETIC FIELD

Alex Vary, North Olmsted, Ohio, assignor to the United States of America as represented by the Administrator of the National Aeronautics and Space Administration

Filed June 24, 1965, Ser. No. 466,868
13 Claims. (Cl. 310—4)

ABSTRACT OF THE DISCLOSURE

A thermionic converter having an electron emitting electrode and a collector electrode disposed in spaced relationship in an envelope, a load being connected between the electrodes. The collector electrode comprises a pair of comb-like elements having intermeshed segments defining alternately narrow and wide spaces. Electrons reaching the collector flow in opposite directions in adjacent segments to produce a magnetic field which aids electron flow from emitter to collector.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates generally to an electrical power source and more particularly to a new and improved thermal-to-electrical energy converter in which heat energy is converted directly into electrical energy.

As well known in the art, one of the more important factors which heretofore has limited the use of thermionic converters to obtain thermal-to-electrical energy conversion has been the effective impedance that is caused by the electron space charge in the inter-electrode region between the electron emitting electrode and the collector electrode.

Normally, the electron flow between the emitter and collector electrodes is limited primarily by two factors; the supply of electrons and the behavior of said electrons after they leave the emitter electrode. At any given temperature of the emitter the supply of electrons given off by said emitter is limited. The more electrons that reach the collector electrode the more efficient is the thermionic conversion of the said device. However, some of the electrons that are given off by the emitter electrode do not cross the inter-electrode space and do not reach the collector electrode because the velocity with which they leave the emitter electrode is not sufficient to carry them through the inter-electrode spacing to the collector electrode. An increase in the supply of electrons may be accomplished by raising the temperature of said emitter so that more free electrons thereof are ejected and escape from the surface tension of the body of the emitter electrode. Only those electrons possessed of a velocity that is greater than a predetermined minimum value which is characteristic of the material used as the emitter electrode, are able to overcome this surface restraint or tension and succeed in escaping. Those electrons which fail to cross the inter-electrode spacing and reach the collector electrode charge the space adjacent to the emitter electrode negatively and leave said emitter relatively positively charged so that an electrostatic field is produced which tends to force the electrons to return to the emitter electrode.

Heretofore, in the development of thermionic conversion devices several developmental improvements have ben made in an effort to overcome these operational and structural limitations among others known in the art.

One such developmental change has been to reduce the inter-electrode spacing between the emitter electrode and collector electrode in an effort to increase the electron flow therebetween and thus limit the effective impedance of the space charge buildup.

Still another attempt to improve the operational efficiency has been to introduce a gas or vapor such as cesium to act as a carrier into the inter-electrode spacing whereby the impedance of the inter-electrode region is intended to be reduced in an effort to enhance the transfer of the electrons therethrough to the collector electrode. For example, in present day thermionic converters cesium vapor is commonly used at pressures ranging from one-tenth to several thousandths of microns of mercury and have been effective to provide a greater efficiency of operation in thermionic converters.

However, in each of the prior art thermionic converters known to present day, an electromagnetic field is generated by the electron current or flow in the inter-electrode space, notwithstanding the changes that have been made to the inter-electrode spacing and/or the spacing impedance. And, consequently, there still exists an important factor which limits the operational efficiency of present day thermionic converters which accounts to a great extent in their being used under only special circumstances.

The above-mentioned electromagnetic field which is established in the inter-electrode space by the electron current flow acts to deflect the electrons back to the emitter electrode. And, inasmuch as current densities of the order of ten to twenty amperes per square centimeter of emitting surface are often realized, this self-induced field can become large enough to reduce the electron transmission to less than one percent if the emitter surface is of the order of a few square centimeters. Therefore, thermionic converters including those defined in the art as large-scale converters having emitters with an area of ten to a hundred square centimeters and current densities of ten or more per square centimeter, cannot be made efficient unless this self-induced electromagnetic field is modified or overcome.

The thermionic converter of the present invention is intended to be uniquely operable to develop an electromagnetic field acting within the inter-electrode spacing between the emitter electrode and the collector electrode whereby the electromagnetic field generated by the electron current is neutralized and/or reduced, so that a substantially larger electron flow is capable of reaching the collector electrode than heretofore possible, to thus form a larger output current flow available for the desired work function.

It is therefore a primary object of the present invention to provide a new and improved thermionic converter which has a substantially high efficiency of thermal-to-electrical energy conversion.

Another object of the present invention is to provide a novel and improved thermionic converter which functions to effectively neutralize and/or reduce the electromagnetic field generated by the electron current to thus enable a larger quantity of electrons to pass through the inter-electrode space to the collector electrode.

Another object of the present invention is to provide a new and improved thermionic converter which may have a variety of electrode configurations and which is especially applicable to both planar and coaxial-cylindrical geometries.

Still another object of the present invention is to provide a new and improved thermionic converter which includes means for producing an electromagnetic field that is substantially perpendicular to the emitting surface of the emitter electrode and which increases the efficiency of the thermionic conversion, said field being established and maintained by the electron flow to the collector electrode.

Another object of the present invention is to provide a new and improved thermionic converter as above described and further wherein the generated electromagnetic field is intended to reduce the portions of the electromagnetic field generated by the electron current which tends to decrease the transfer of electrons to the collector, and to provide optimum collector electrode areas where the density of the electron flow is greatest.

Additional objects and advantages of the thermionic converter of the present invention will become apparent to one skilled in the art to which it pertains, and upon reference to the several preferred embodiments that are described herein and which are illustrated in the accompanying drawings wherein:

FIG. 1 is a schematic wiring diagram illustrating the circuit configuration of a diode-type of thermionic converter embodying the present invention;

FIG. 2 is a fragmentary isometric view showing a configuration of diode-type of thermionic converter in which the electrodes are of planar configuration;

FIG. 3 is a sectional view taken approximately on the line 3—3 of FIG. 2;

FIG. 4 is a sectional view of a modified form of planar embodiment of diode thermionic converter; and

FIG. 5 is a sectional view of a coaxial cylindrical embodiment of diode thermionic converter embodying the present invention.

Briefly, the invention described herein provides a novel and improved thermionic converter wherein the electron current flow passing through the collector electrode establishes and maintains a secondary electromagnetic field which is of sufficient magnitude to substantially neutralize and/or materially reduce the effects of the primary electromagnetic field generated by the electron current.

And, as will be hereinafter realized, the concepts of the present invention are readily applicable to both planar and cylindrical geometries of converter assemblies as also various other structural equivalents thereof.

With reference now directed to FIG. 1, there is herein shown the electrical schematic configuration of a typical circuit employing a diode type of thermionic converter embodying the present invention.

As will be realized, the converter assembly is intended to be incorporated into a suitable closed envelope as schematically indicated at E whereby the interior thereof is substantially void of air. A suitable gaseous vapor may also be placed within the envelope to act as a carrier in an effort to reduce the effective impedance of the inter-electrode spacing. The emitter electrode assembly is seen to consist of electrode element *e* spaced closely adjacent the collector electrode assembly *c* to define the inter-electrode space *s* therebetween.

The collector electrode assembly comprises a pair of comb-like elements *d* and *k* having their respective elongated electrode segments *x* and *o* intermeshed in a particular spacing arrangement as will be presently described. The collector element *d* has each of its *x* segments preferably integrally formed with a bus bar *g*, and in like manner the collector electrode element *k* has each of its *o* segments integrally formed on an end with a bus bar *j*. Each of said collector bus bars *g* and *j* is, in turn, connected by a conductor *m, n* to one end of the converter load, the emitter electrode *e* being connected by conductor *p* to the opposite end of said load as herein shown.

With heat applied to the emitter electrode *e* sufficient to cause electrons to be ejected therefrom and into the interelectrode spacing *s* whereby some of said electrons reach the collector electrode *c*, an electron flow occurs in the separate collector segments *x* and *o* in the direction of the arrows *a, b* respectively. With said segments connected by conductors *m, n,* to the load, said electron flow is thus applied to said load.

With reference now directed to FIGS. 2 and 3, a planar configuration of diode thermionic converter incorporating the present invention is herein disclosed. In this converter assembly the emitter electrode **2** is seen to comprise a flat rectangular plate which is spaced closely adjacent the collector electrode assembly **4** to define the inter-electrode space **6** therebetween. The converter assembly is likewise intended to be incorporated within a suitable closed envelope E, the interior of which is substantially exhausted of air and/or which contains a suitable vapor carrier.

The collector electrode **4** comprises a pair of rectangular-shaped camb-like electrode elements **8** and **10**, electrode element **8** having a plurality of elongated finger-shaped segments **12** depending downwardly from a bus bar **14**, said electrode segments being interspaced between upwardly projecting similarly shaped electrode segments **16** of collector electrode element **10** preferably formed integrally with bus bar **18**.

As best seen in FIG. 3, the collector electrode elements **8** and **10** are disposed adjacent the emitter electrode **2** whereby to locate their respective electrode segments **12** and **16** in an intermeshed relation such that the spacing between successive pairs of collector electrode segments is alternately narrow and wide. For example, the spacing **20** between the first pair of electrode segments **12** and **16** as shown at the left of the assembly in FIG. 3, is narrow with respect to the spacing identified at **22** formed between the electrode segment **16** of said first pair and the next adjacent electrode segment **12** disposed to the right thereof to constitute the next successive electrode pair. And, as seen in FIG. 3, this spaced relation exists for the remaining pairs of electrode segments **12, 16.**

With this particular emitter and collector electrode structure, as heat is applied to said emitter electrode **2** sufficient to emit electrons therefrom, some of which reach the collector electrode assembly **4**, those electrons which strike the electrode segments **12** will flow in an upward direction therethrough as is shown in FIG. 2 by the arrow W, whereas those electrons which strike the electrode segments **16** of element **10** will flow in the opposite or downward direction as is shown in FIG. 2 by the arrow Y. The direction of flow of heat energy is diagrammatically illustrated by arrows H in FIG. 3.

As will be understood, the electron flow in the electrode segments **12** and **16** will create a secondary electromagnetic field surrounding each of said electrode segments, said field being best illustrated in FIG. 3, and which has a unique configuration as a result of the spacing arrangement between said segments.

For example, with respect to each of the electrode segments **12**, as shown in FIG. 3, the electron flow is away from the observer as herein shown and creates an electromagnetic field **26** around said segment in a clockwise direction.

In like manner, the electron current flow in each adjacent electrode segment **16** flows upwardly therethrough toward the observer and generates an electromagnetic field **30** in a counterclockwise direction.

The electromagnetic field thus generated in each electrode segment may be divided into three basic components in the inter-electrode region or space **6** where its effect is rendered.

First, it has a component that is substantially parallel to the emitter electrode and which tends to deflect electrons back to said emitter electrode. This parallel component of said field is identified in FIG. 3 by the reference numeral v_1.

Said field also has a component which is perpendicular to and directed toward the emitter electrode which also retards the electron flow in said inter-electrode space to thus reduce transmission of electrons. This perpendicular component is identified in FIG. 3 by the reference numeral v_2. As will be noted, the field component v_2 produced by spaced pairs of electrode segments **16, 12** are cumulative in the electrode spacing **22** and are dominant in said spacing to impede electron flow to the collector electrode.

The electromagnetic field also has a component that is perpendicular to and directed toward the collector electrode **4** and which is used to effect an increase in the transmission of electrons across the inter-electrode spacing **6**. This perpendicular component is identified in FIG. 3 by the reference numeral v_3.

As will be seen in FIG. 3, the field component v_3 produced by spaced pairs of electrode segments **12**, **16** are cumulative in the spacing **20** and are dominant therein to enhance the flow of electrons to the collector electrode assembly **4**.

As will be apparent, the intensity of the field component v_3 in the zone of the electrode spacing **20** is greater than the intensity of the field component v occurring in the zone of electrode spacing **22**, inasmuch as the latter component is somewhat diffused in said relatively larger electrode spacing **22**.

Further, the intensity of the field component v_3 acts to funnel or draw the electrons from the emitter electrode toward the collector electrode assembly **4** principally in the area of the electrode spacing **20**, while the somewhat diffused field component v_2 acts to direct electrons back toward the emitter and into the area of the field component v_3.

As a result, the direction of the net electron flow in the interelectrode space **6** is in the same direction as the flow of heat energy as shown by the arrows H in FIG. 3. Also, the field component v_1 that is substantially parallel to the emitter electrode surface in the interelectrode spacing **6** *tends to channel the electrons in said region toward* the spaced zones of greatest field intensity as defined by the field component v_3.

Principally, because the electrode materials are selected to be magnetically permeable, the lines of force of the generated field will penetrate into the emitter as indicated in FIG. 3 by the typical lines of force, and thereby result in providing regions on the emitter surface in which each of the three field components v_1, v_2 and v_3 is prominent. These regions will occur in a series of triple bands in a cyclic series.

For example, the electromagnetic field component v_1 is predominant in the interelectrode spacing **6** directly between the emitter electrode **2** and collector electrode assembly **4**.

The field component v_2 of said electromagnetic field is predominant in each space **22** between adjacent pairs of electrode segments **16** and **12** as viewed from left to right in FIG. 3 whereas the perpendicular component v_3 directed toward the collector electrode assembly **4** is predominant in each space **20** between the adjacent pairs of electrode segments **12**, **16** of the collector electrode assembly **4**.

The collector electrode segments **12**, **16** are each presumed to receive a fairly uniform electron flux over their full length and therefore the current in an incremental length of a given segment has the magnitude that is determined by the integral of all incremental currents reckoned from the free end of said segment.

However, because of the current gradient along each electrode segment there is a corresponding electromagnetic field gradient and inasmuch as adjacent electrode segments carry an electron current flow in the opposite direction with respect to its immediate neighboring segment on either side thereof the resultant field, especially the perpendicular components thereof, are uniform between adjacent electrode segments as a result of the superposition of intermeshed relationship of said segments. And, as before mentioned, because of the space **20** being smaller than the space **22** between adjacent electrode segments **12**, **16** the resultant intensity of the field in space **20** is substantially greater than the intensity of the field in space **22**.

The planar-type of converter assembly as thus far described, may be further modified to enhance electron transmission. This may be accomplished by providing the emitter electrode **2** with a configuration that is similar to that of the collector electrode **4**.

This modified assembly is seen in FIG. 4 wherein the emitter electrode comprises a plurality of spaced electrode segments **2*a*** and **2*b*** which are located opposite the collector segments **12** and **16** to enhance the perpendicular field components v_2 and v_3. The interelectrode spacing between the emitter and collector electrodes is shown at **20*a***. The results are the reduction and/or cancellation of component v_1 and the strengthened perpendicular components v_2 and v_3. Each alternate emitter segment **2*a*** and **2*b*** is connected to or integrally formed with bus bars **3*a*** and **3*b*** at one end so that the magnetic lines of face assume a clockwise or counterclockwise direction corresponding to the direction associated with the opposite collector segment, FIG. 4.

In FIG. 5, a coaxial cylindrical embodiment of a two-element diode-type of thermionic converter is herein disclosed.

In this assembly, the emitter electrode **40** is cylindrical in configuration and has a suitable heating element **42** inserted therein.

The collector electrode as identified at **43**, comprises a pair of cage-like cylindrical electrodes preferably of equal diameter, each having a plurality of electrode segments **47**, **48** disposed in circumferentially spaced relation and extending longitudinally along the cylinder axis and enclosing the emitter electrode to define the inter-electrode space **50** therebetween.

The electrode segments **47**, **48** of each electrode are commonly connected to or preferably formed integrally with a bus bar shown schematically at **47*a***, **48*a*** respectively to which the converter load is connected as in the previous embodiment.

The collector electrodes are superimposed one over the other with the bus bars **47*a***, **48*a*** located on opposite ends of the resulting assembly and to locate the segments **47**, **48** in closely spaced relation to each other defining alternate wide and narrow spacing **52**, **53** between successive pairs of said segments.

As in the previous embodiments of thermionic converters with the emitter heated by source **42** sufficiently to eject electrons therefrom, the disposition of the collector segments **47*a***, **48*a*** assure counterflow of electrons between adjacent segments whereby in the narrow spacing **53** the intensity of the electromagnetic field generated by said electron flow is substantially greater than the field intensity in the wide spacings **52** wherein said field is somewhat diffused.

As a result, the outward flow of electrons toward the collector electrode assembly is enhanced in the region of narrow spacings **53** wherein the outwardly directed perpendicular component of the electromagnetic field f_3 is *maximum and inhibited in the region of relatively wide* spacings **52** wherein the oppositely directed perpendicular component f_2 of said field is diffused in said relatively wide spacings **52**.

As will be realized, the net flow of electrons in the interelectrode space **50** is radially outward as is the flow of heat energy from the emitter heat source, the latter being identified by the arrows *h*.

Further, the secondary self-induced field generated by the electron flow in the collector electrode assembly also provides a radial magnetic field with respect to the axis of the emitter and collector electrodes, the net effect of said field acting to induce the flow of electrons toward the collector electrode.

Having thus described several preferred embodiments of thermionic converter of the present invention it will now be apparent that the inventive concepts herein provide a novel thermionic converter assembly which is especially designed to use the output current flowing through the collector electrode assembly to establish and maintain a secondary self-induced electromagnetic field having a component that is substantially perpendicular to and directed away from the emitter surface whereby this secondary self-induced field is made sufficiently strong to overcome the effect of the primary self-induced field, and thus enhances electron flow to the collector electrode. Further, the invention is readily applicable to both planar and cylindrical geometries as well as structural equivalents thereof and is especially operable to solve the problem of producing a radial secondary self-induced magnetic field that includes a perpendicular component for the coaxial-cylindrical configuration of converter.

Likewise, the shape and structure of the collector electrode assembly, in addition to producing the second self-induced field, is also constructed to have a plurality of segments which are so aligned and spaced as to take advantage of the perpendicular component directed away from the emitter electrode. Likewise, the spacing of the collector electrode segments is such as to provide the maximum collector electrode surface in those regions where the greatest electron impingement occurs.

And, further, it is also seen that the emitter electrode may consist of a similar configuration to augment the outwardly directed perpendicular component of the secondary field. Thus, the electron flow in both electrodes may be used to establish appropriate fields to enhance the electron transmission therebetween.

Having thus described several preferred embodiments of thermionic converters embodying the present invention it will be realized that the same is susceptible to various modifications, combinations and arrangement of parts without departing from the inventive concepts as are defined in the claims.

I claim:

1. A thermionic converter comprising an emitter electrode, a collector electrode disposed in closely spaced relation to said emitter electrode to define an inter-electrode space therebetween, said collector electrode having a plurality of electrode segments disposed in closely spaced relation to each other, means enveloping said emitter and collector electrodes in a closed atmosphere, said emitter electrode being adapted to emit electrons into said inter-electrode space, at least a portion of said emitted electrons striking and being collected on said electrode segments, and said electrode segments being adapted to be connected into a load circuit whereby to effect an electron flow in opposite directions in adjacent segments which is effective to generate an electromagnetic field that is operable to increase the flow of electrons to said electrode segments.

2. A thermionic converter comprising an emitter electrode, a collector electrode disposed in closely spaced relation to said emitter electrode to define an inter-electrode space therebetween, means enveloping said emitter and collector electrodes in a closed atmosphere, said emitter electrode being adapted to emit electrons into said inter-electrode space, said collector electrode comprising at least a pair of elements each having a plurality of elongated segments, said elements being disposed to locate said segments in an intermeshed relation with each segment of one of said pair of elements adjacent a segment of the other of said pair of elements, at least a portion of said emitted electrons striking and being collected on said collector electrode segments, and means connecting the segments of each element together to provide for electrons to flow in opposite directions in adjoining segments for generating an electromagnetic field between the emitter electrode and collector electrode which is operable to increase the flow of electrons to said segments.

3. A thermionic converter comprising an emitter electrode, a collector electrode disposed in closely spaced relation to said emitter electrode to define an inter-electrode space therebetween, means enveloping said emitter and collector electrodes in a closed atmosphere, said

emitter electrode being adapted to emit electrons into said inter-electrode space, said collector electrode comprising at least a pair of elements of planar configuration and having a plurality of elongated segments disposed in spaced relation to each other, said pair of elements being disposed to locate said segments in an intermeshed relation with each segment of one of said pair being adjacent a segment of the other of said pair, at least a portion of said emitted electrons striking and being collected on said collector electrode segments, and means connecting the segments of each element together to provide for electrons to flow in opposite directions in adjoining segments effective to generate an electromagnetic field between the emitter electrode and collector electrode which is operable to increase the flow of electrons to said segments.

4. A thermionic converter comprising an emitter electrode, a collector electrode disposed in closely spaced relation to said emitter electrode to define an inter-electrode space therebetween, means enveloping said emitter and collector electrodes in a closed atmosphere, said emitter electrode being adapted to emit electrons into said inter-electrode space, said collector electrode comprising at least a pair of elements of cylindrical configuration and each having a plurality of elongated segments disposed in spaced relation to each other, said pair of elements being disposed to locate said segments in an intermeshed relation with each segment of one of said pair adjacent a segment of the other of said pair, at least a portion of said emitted electrons striking and being collected on said collector electrode segments, and means connecting the segments of each element together to provide for electrons to flow in opposite directions in adjoining segments effective to generate an electromagnet field between the emitter electrode and collector electrode which is operable to increase the flow of electrons to said segments.

5. A thermionic converter comprising an emitter electrode, a collector electrode disposed in closely spaced relation to said emitter electrode to define an inter-electrode space therebetween, means enveloping said emitter and collector electrodes in a closed atmosphere, said emitter electrode being adapted to emit electrons into said inter-electrode space, said collector electrode comprising at least a pair of elements each having a plurality of elongated segments, said elements being disposed to locate said segments in an intermeshed relation with each segment of one of said pair adjacent a segment of the other of said pair, at least a portion of said emitted electrons striking and being collected on said collector electrode segments, bus bar means connecting to the end of each segment of each element to provide for electrons to flow in opposite directions in adjoining segments effective to generate an electromagnetic field between the emitter electrode and collector electrode which is operable to increase the flow of electrons to said segments.

6. In a thermionic converter as is defined in claim 5 and wherein the electromagnetic field has a component that is directed toward the emitter electrode and perpendicular to its surface.

7. In a thermionic converter as is defined in claim 5 and wherein the electromagnetic field has a component that is directed substantially perpendicularly away from the surface of the emitter electrode effective to enhance the passage of electrons to the collector electrode.

8. A thermionic converter comprising an emitter electrode, a collector electrode disposed in closely spaced relation to said emitter electrode to define an inter-electrode space therebetween, means enveloping said emitter and collector electrodes in a closed atmosphere, said emitter electrode being adapted to emit electrons into said inter-electrode space, said collector electrode comprising at least a pair of elements each having a plurality of elongated segments, said elements being disposed to locate said segments in an intermeshed spaced relation

with each segment of one of said pair adjacent a segment of the other of said pair, the spacing between the segments of alternate pairs being of smaller dimension with respect to the dimension of the spacing of the segments of the next adjacent pair, at least a portion of said emitted electrons striking and being collected on said collector electrode segments, and means connecting the segments of each element together to provide for electrons to flow in opposite directions in adjoining segments for generating an electromagnetic field between the emitter electrode and collector electrode which is operable to increase the flow of electrons to said segments.

9. In a thermionic converter as is defined in claim **8** and wherein the elements of the collector electrode are each of planar configuration.

10. In a thermionic converter as is defined in claim **8** and wherein the elements of the collector electrode are each substantially cylindrical in configuration.

11. In a thermionic converter as is defined in claim **8** and wherein the electromagnetic field has a component that is predominant in the spacing between the collector electrode segments of smaller dimension and which component is directed substantially perpendicularly outwardly from the surface of the emitter electrode effective to enhance the transmission of electrons to said collector electrode.

12. In a thermionic converter as is defined in claim **8** and wherein the electromagnetic field has a component that is predominant in the spacing between the collector electrode segments of greater dimension and which is directed substantially toward the emitter electrode effective to inhibit the passage of electrons to the collector electrode.

13. In a thermionic converter as is defined in claim **8** and wherein the emitter electrode comprises a plurality of spaced segments each of which is disposed opposite to the spacing of smaller dimension between alternate pairs of collector electrode segments.

References Cited

UNITED STATES PATENTS

3,110,823	11/1963	Gabor	310—4
3,202,844	8/1965	Hatch	310—4

MILTON O. HIRSHFIELD, *Primary Examiner.*

DAVID X. SLINEY, *Assistant Examiner.*